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STATEMENT OF ACCURACY OF TRANSLATION
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The undersigned translator, having an office at

states that:

(1) I am fully conversant both with the Japanese and English languages.

(2)(A) I have translated into English, Japanese Patent Application Number 295440/1999, filed October 18, 1999. A copy of said English translation is attached hereto.

(2)(B) I have carefully compared the attached English-language translation of Japanese Patent Application Number _____ filed _____ with the original Japanese-language patent application.

(3) The translation is, to the best of my knowledge and belief, an accurate translation from the original into the English language.

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[Name of Document] SPECIFICATION

[Title of Invention] COMPOSITE MAGNETIC BODY AND ELECTRO-MAGNETIC INTERFERENCE SUPPRESSOR USING THE SAME

[Claim for Patent]

[Claim 1] A composite magnetic body, comprising soft magnetic powder and silicone rubber.

[Claim 2] A composite magnetic body as claimed in claim 1, wherein said silicone rubber is solid silicone rubber.

[Claim 3] A composite magnetic body as claimed in claim 1, wherein said silicone rubber is reaction-setting silicone rubber of a liquid phase.

[Claim 4] A composite magnetic body as claimed in any one of claims 1 to 3, wherein said silicone rubber contains an additive comprising at least one of carbon black and one or more elements selected from platinum, silicon, titanium, iron, copper, nickel, and cobalt.

[Claim 5] A composite magnetic body as claimed in any one of claims 1 to 4, wherein said soft magnetic powder is magnetic alloy powder having a flat shape.

[Claim 6] A composite magnetic body as claimed in any one of claims 1 to 4, wherein said soft magnetic powder has a surface area of 0.1 m^2/g-3 m^2/g.

[Claim 7] A composite magnetic body as claimed in any one of claims 1 to 4, wherein said soft magnetic powder is magnetic alloy powder having a flat shape and has a surface area of 0.1 m^2/g-3 m^2/g.

[Claim 8] A composite magnetic body as claimed in any one of claims 1 to 7, wherein said soft magnetic powder has an aspect ratio of 3 or more.

[Claim 9] A composite magnetic body as claimed in any one of claims 1 to 8, wherein said soft magnetic powder is surface-treated with a coupling agent having a SP value ranging from 6 to 10.

[Claim 10] A composite magnetic body as claimed in claim 9, wherein said coupling agent is any one of titanate-based, aluminate-based, and silane-based coupling agents.

[Claim 11] A composite magnetic body as claimed in any one of claims 1 to 8, wherein said soft magnetic powder is surface-treated with a primer having a SP value smaller than the SP value of said soft magnetic powder and greater than the SP value of said silicone rubber.

[Claim 12] An electromagnetic interference suppressor using a composite magnetic body claimed in any one of claims 1 to 11, said electromagnetic interference suppressor suppressing electromagnetic interference caused by the interference from undesired electromagnetic waves.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

This invention relates to a composite magnetic body for use in suppressing electromagnetic interference caused by the interference from undesired electromagnetic waves in a high-frequency region and an electromagnetic interference suppressor using the same. In particular, this invention relates to a technique of preparing fireproofing composition which contains no halogen in view of the safety for the environment.

[0002]

[Prior Art]

In recent years, use is widely made of various electronic apparatuses, such as a mobile telephone or a personal computer, which utilize a high frequency. In particular, the demand for the reduction in size and weight is

prominent and electromagnetic noise interference becomes a serious problem. In view of the above, composite magnetic bodies and electromagnetic interference suppressors have been commercialized as a countermeasure against such high-frequency electromagnetic interference.

[0003]

Traditionally, in composite magnetic bodies and electromagnetic interference suppressors using the same, a halogen-based fire retardant or antimony trioxide as a fire retardant aid are used as a measure for fireproofing. Such fireproofing techniques are common and typically applied to coating materials for electric wires or the like and casings for electronic apparatuses.

[0004]

In some composite magnetic bodies, chlorinated polyethylene is used as a binding agent in order to improve a filling characteristic of soft magnetic powder and a fire resistant characteristic. In this case also, chlorine, i.e., halogen is contained.

[0005]

[Problem to be Solved by the Invention]

However, it has been pointed out that, during incineration disposal of chlorine-containing materials, dioxins might be produced depending upon incineration conditions, although many unclear points are still left.

[0006]

In addition, a sort of dioxins might possibly be produced from halogen-containing materials such as the fire retardant, although conclusion is not made because of absence of precise and detailed reports.

[0007]

In recent years, following the increase in safety awareness with respect to the environmental problems and the human health, there arises a demand for the development of materials which do not contain the above-

mentioned substances and therefore reduce the load upon the environment.

[0008]

It is therefore an object of this invention to provide a composite magnetic body and an electromagnetic interference suppressor which are completely free from halogen-containing materials, such as halogen-based resin and elastomer as a binding agent and a halogen-containing bromine-based fire retardant.

[0009]

[Means to Solve the Problem]

In order to solve the above-mentioned technical problem, in this invention, a composite magnetic body are rendered fire resistant without using a halogen-based binding agent excellent in powder filling characteristic or a halogen-based fire retardant having a high fireproofing effect.

[0010]

This invention provides a composite magnetic body, comprising soft magnetic powder and silicone rubber.

[0011]

This invention also provides a composite magnetic body, wherein the silicone rubber is solid silicone rubber.

[0012]

This invention also provides a composite magnetic body, wherein the silicone rubber is reaction-setting silicone rubber of a liquid phase.

[0013]

This invention also provides a composite magnetic body, wherein the silicone rubber contains an additive comprising at least one of carbon black and one or more elements selected from platinum, silicon, titanium, iron, copper, nickel, and cobalt.

[0014]

This invention also provides a composite magnetic body, wherein the soft magnetic powder is magnetic alloy powder having a flat shape.

[0015]

This invention also provides a composite magnetic body, wherein the soft magnetic powder has a surface area of 0.1 m^2/g-3 m^2/g.

[0016]

This invention also provides a composite magnetic body, wherein the soft magnetic powder is magnetic alloy powder having a flat shape and has a surface area of 0.1 m^2/g-3 m^2/g.

[0017]

This invention also provides a composite magnetic body, wherein the soft magnetic powder has an aspect ratio of 3 or more.

[0018]

This invention also provides a composite magnetic body, wherein the soft magnetic powder is surface-treated with a coupling agent having a SP value ranging from 6 to 10.

[0019]

This invention also provides a composite magnetic body, wherein the coupling agent is any one of titanate-based, aluminate-based, and silane-based coupling agents.

[0020]

This invention also provides a composite magnetic body, wherein the soft magnetic powder is surface-treated with a primer having a SP value smaller than the SP value of the soft magnetic powder and greater than the SP value of the silicone rubber.

[0021]

This invention also provides an electromagnetic interference suppressor using a composite magnetic body described above, the

electromagnetic interference suppressor suppressing electromagnetic interference caused by the interference from undesired electromagnetic waves.

[0022]

[Mode of Embodying the Invention]

Now, description will be made about embodiments of this invention.

[0023]

Fig. 1 is a schematic sectional view showing the structure of a composite magnetic body according to an embodiment of this invention. As shown in Fig. 1, a composite magnetic body 1 comprises flat soft magnetic powder 2 whose planar surface is oriented along one plane (horizontal plane in Fig. 1) and a binding agent 3 comprising silicone rubber.

[0024]

Herein, the composite magnetic body serves as an electromagnetic interference suppressor for suppressing electromagnetic interference caused by the interference from undesired electromagnetic waves in case where the composite magnetic body is used in an internal part or a peripheral part of an electrical apparatus or the like. In this embodiment, the composite magnetic body is a product which has a composition described later and which is produced by the use of a method described later. On the other hand, the composite magnetic body thus obtained will be referred to as an electromagnetic interference suppressor in case where it is used in an internal part or a peripheral part of an electrical apparatus or the like. In other words, the composite magnetic body and the electromagnetic interference suppressor are same in view of the composition and the production process but are different in view of the application. Accordingly, different expressions are used. It is to be noted that the terms of the composite magnetic body and the electromagnetic interference suppressor are selectively used from the above-mentioned reason in the following description.

[0025]

Silicone rubber involved in this invention is described in, for example, the item "silicone" in the Dictionary of Physics and Chemistry published by Iwanami Shoten. It is mentioned that "Polymers whose main chains are composed of repeating siloxane bonds–$(Si\text{-}O)_n$– and whose side groups are composed of alkyl, aryl, or the like are collectively referred to as silicone. Not to be confused with silicon. Resulting from the above-mentioned molecular structure, silicone has excellent physical properties such as heat resistance, water repellency, electrical insulation, chemical resistance, aging resistance. Depending on the degree of polymerization, the type of the side group, the extent of cross-linking, and the like, silicone can be in the form of liquid, grease, rubber, or resin. The one having a linear structure, a low degree of polymerization, and fluidity at room temperature is called silicone oil and is typically a polymer of dimethyl dichlorosilane. The one obtained by moderate cross-linking of linear polydimethylsiloxane with a high degree of polymerization or a copolymer thereof to exhibit rubber-like elasticity is called silicone rubber. A solid-state one obtained by hydrolysis and polycondensation of a chlorosilane derivative $R_nSiCl_{(4-n)}$ and having a highly developed three-dimensional network structure is called silicone resin or silicon resin."

[0026]

(First Embodiment)

Now, description will be made about a composite magnetic body and an electromagnetic interference suppressor according to one embodiment of this invention.

[0027]

The mixing composition of the composite magnetic body according to a first embodiment of this invention is shown as Example 1 in the following Table 1. As a filler, use is made of Fe-Si-Al alloy powder which is one of soft

magnetic powder. It is noted here that, by the use of a Fe-Si-Al-Ni based composition or the like as soft magnetic powder, the equivalent result can be obtained. Example 1 uses the composition of 6–11 wt% Si, 4–7 wt% Al, and the balance Fe. The powder has an average grain size of 32 μm.

[0028]

First, 273 weight parts of the soft magnetic powder, 100 weight parts of solid silicone rubber as a binding agent, and 2 weight parts of a cross-linking agent are kneaded by the use of a mixing roll to obtain a kneaded magnetic material. The kneading operation may be carried out by the use of a kneading machine, such as a kneader and an intensive mixer. In this case also, the equivalent kneaded magnetic material can be obtained.

[0029]

Next, the kneaded composite magnetic material thus obtained is rolled between rolls arranged in parallel to obtain a sheet-like composite magnetic body. In order to obtain such a sheet-like composite, use may be made of a molding method, such as extrusion, press molding, and injection molding in addition to the above-mentioned rolls, which is capable of forming a desired shape,.

[0030]

Subsequently, the sheet thus obtained is heat-pressed to cause cross-linking reaction. Thus, the sheet-like composite magnetic body is obtained.

[0031]

The composite magnetic body produced in the above-mentioned manner is used in an internal part or a peripheral part of an electrical apparatus or the like. Then, the composite magnetic body serves as an electromagnetic interference suppressor for suppressing electromagnetic interference caused by the interference from undesired electromagnetic waves.

[0032]

For the purpose of comparison with Example 1, a conventional example is also shown in the following Table 1. In order to facilitate comparison, production was carried out in the manner similar to Example 1.

[0033]

The conventional example is remarkably different from the above-mentioned Example in that halogen-containing chlorinated polyethylene is used as a binding agent and a halogen-containing bromine-based polymer fire retardant is used as a fire retardant. In addition, antimony trioxide is used as a fire retardant aid.

[0034]

(Second Embodiment)

The mixing composition of a composite magnetic body according to a second embodiment of this invention is shown in the following Table 1, together with Example 1.

[0035]

As a filler, use is made of Fe-Si-Al alloy powder which is same as that used in Example 1. Like in Example 1, by the use of a Fe-Si-Al-Ni based composition or the like as soft magnetic powder, the equivalent result can also be obtained.

[0036]

First, 273 weight parts of the Fe-Si-Al alloy powder as the soft magnetic powder mentioned above and 100 weight parts of a two-part silicone rubber including a main part and a curing agent, that is, the total amount of 373 weight parts, are stirred by a mixer. A resultant composite magnetic material mixed and uniformly dispersed is molded by an injection-molding machine to obtain the composite magnetic body. Herein, an injection-molding die is formed into a sheet-like shape so that the mixture was cured into a composite

magnetic sheet. In order to obtain the composite magnetic material in this Example, use may be made of an extruder, press molding, or roll molding.

[0037]

(Third Embodiment)

The mixing composition of a composite magnetic body according to a third embodiment of this invention is shown in the following Table 1, together with Examples 1 and 2.

[0038]

As a filler, use is made of Fe-Si-Al alloy powder as the above-mentioned soft magnetic powder, like in Example 1. In addition, by the use of a Fe-Si-Al-Ni based composition or the like as the soft magnetic powder, the equivalent result can also be obtained.

[0039]

First, in Example 3, 273 weight parts of the Fe-Si-Al alloy powder as the soft magnetic powder mentioned above and 100 weight parts of a one-part silicone rubber, that is, the total amount of 373 weight parts, are stirred by a mixer. Like in Example 2, a resultant composite magnetic material mixed and uniformly dispersed is molded by an injection-molding machine to obtain the composite magnetic body. Herein, an injection-molding die is formed into a sheet-like shape so that the mixture was cured into a composite magnetic sheet. In order to obtain the composite magnetic material in this Example 3, use may be made of an extruder, press molding, or roll molding.

[0040]

[Table 1]

Mixing Composition	Example 1 (weight parts)	Example 2 (weight parts)	Example 3 (weight parts)	Conventional Example (weight parts)
(Binding Agent) silicone rubber (solid type)	100			
silicone rubber (2-part type)		100		
silicone rubber (1-part type)			100	
chlorinated polyethylene				100
(Filler: Soft Magnetic Powder) Fe-Al-Si alloy Average Grain Size: 32 μ m	273	273	273	273
(Fire Retardant) bromine-based polymer fire retardant	0	0	0	20
(Fire Retardant Aid) antimony trioxide	0	0	0	20
(Cross-Linking Agent) peroxide	2	0	0	2

[0041]

Next, the following Table 2 shows the results of burning tests for component magnetic sheets obtained in Examples 1 to 3 and the conventional example. Since the composite magnetic body is often used in an electronic component, the burning test was carried out by the use of the Vertical Burning Test UL 94V in accordance with the UL Safety Standards for the flammability test of plastic materials for equipment parts. Each of samples had a length of 127 mm, a width of 12.7 mm, and a thickness of 0.3 mm. The Vertical Burning Test was carried out by the use of five specimens of samples Nos. 1–5. The column of "First Afterflame" shows the combustion time (seconds) after a first flame contact, the column of "Second Afterflame" shows the combustion time (seconds) after a second flame contact, and the column of "Second Afterflame + Glowing" shows the total of the combustion time and the glowing time after

the second flame contact. The glowing time means the time duration of non-flaming combustion after flaming combustion has stopped or in case of a material which does not cause flaming combustion.

[0042]

[Table 2]

Example 1	No.	Thickness (mm)	First Afterflame	Second Afterflame	Second Afterflame + Glowing	Class
silicone rubber (solid type)	1	0.30	19	31	57	Horizontal Burning Test HB
	2	0.30	25	26	36	
	3	0.30	23	33	50	
	4	0.30	20	34	48	
	5	0.30	32	20	36	

Example 2	No.	Thickness (mm)	First Afterflame	Second Afterflame	Second Afterflame + Glowing	Class
silicone rubber (2-part type)	1	0.30	25	27	54	Horizontal Burning Test HB
	2	0.30	28	30	55	
	3	0.30	26	28	53	
	4	0.30	33	28	55	
	5	0.29	26	35	58	

Example 3	No.	Thickness (mm)	First Afterflame	Second Afterflame	Second Afterflame + Glowing	Class
silicone rubber (1-part type)	1	0.30	28	23	56	Horizontal Burning Test HB
	2	0.30	30	29	58	
	3	0.30	28	33	56	
	4	0.29	27	29	55	
	5	0.30	31	22	35	

Conventional Example	No.	Thickness (mm)	First Afterflame	Second Afterflame	Second Afterflame + Glowing	Class
chlorinated polyethylene halogen-based fire retardant	1	0.30	2	1	5	V-0 pass
	2	0.30	4	2	6	
	3	0.30	3	2	6	
	4	0.30	4	1	4	
	5	0.30	3	1	5	

[0043]

The conventional example can meet Class V-0 requirements in the vertical test in accordance with the Flame Resistant Standard UL 94V. However, as described above, chlorinated polyethylene is used as the binder and a halogen-based and bromine-based fire retardant is used as the fire retardant. The content of halogen is about 10%, assuming the overall weight of the composite magnetic body is 100.

[0044]

On the other hand, Example 1 mentioned above contains no halogen. Thus, a so-called non-halogen composition can be achieved. However, this

example does not meet Classes V-0 and V-1 requirements in the UL 94V Vertical Burning Test of the same standard. However, this example meets the requirements in the UL 94HB Horizontal Burning Test which is a lower standard than the UL 94V Vertical Burning Test.

[0045]

Also, the reaction-setting silicone rubber of a liquid phase in Examples 2 and 3 does not meet the Class V-0 and V-1 requirements in the UL 94V Vertical Burning Test but meets the requirements in the UL 94HB Horizontal Burning Test which is a lower standard than the above-mentioned standard in fire resistant characteristic. As described above, the composite magnetic body can be produced by filling the soft magnetic powder in silicone rubber as a halogen-free binding agent. It has been confirmed that the fire resistant characteristic corresponds to UL 94HB Class.

[0046]

Further improvement of fireproofing is tried by the use of an approach of fireproofing the silicone rubber as the binding agent.

[0047]

Table 3 shows the combustion times in cases where various fire retardants are added to 100 weight parts of silicone rubber as fire resistant compositions. As compared with the use of silicone rubber alone, the combustion time is shortened by 24 to 45 seconds. This is because the addition of the fire retardant exhibits the effect of delaying the decomposition of siloxane bond as a main chain of silicone rubber during combustion so that the combustion can be suppressed. Further studies are performed for fireproofing of the composite magnetic body by using, as additives, platinum, silicon dioxide, and carbon black among the various fire retardants.

[0048]

[Table 3]

	Additive	Amount	Combustion Time
Mixture 1	platinum silicon dioxide	55ppm 60	43
2	platinum silicon dioxide carbon black	55ppm 60 2	22
3	platinum silicon dioxide ferrous oxide	55ppm 60 5	32
4	platinum silicon dioxide ferric oxide	55ppm 60 5	33
5	platinum silicon dioxide titanium oxide	55ppm 60 5	30
6	platinum silicon dioxide copper dioxide	55ppm 60 5	41
7	platinum silicon dioxide nickel	55ppm 60 5	40
8	platinum silicon dioxide nickel	55ppm 60 5	40
silicone rubber alone		0	67

[0049]

(Fourth Embodiment)

The mixing composition of a composite magnetic body according to a fourth embodiment of this invention is shown as Example 4 in the following Table 4. For the purpose of comparison, the mixing composition is similar to that of Example 1 except the above-mentioned fire retardant is added to silicone rubber.

[0050]

[Table 4]

Mixing Composition	Example 4 (weight parts)
(Binding Agent) silicone rubber (solid type)	100
(Fire Retardant) platinum silicon dioxide carbon black	55ppm 60 2
(Filler: Soft Magnetic Powder) Fe-Al-Si alloy Average Grain Size: 32 μ m	273
(Cross-Linking Agent) peroxide	2

[0051]

First, 100 weight parts of solid silicone rubber as a binding agent, 2 weight parts of a cross-linking agent, and 55 ppm weight parts of platinum, 60 weight parts of silicon dioxide, and 2 weight parts of carbon black as a fire retardant are kneaded by a mixing roll to be dispersed. The mixture thus obtained is mixed with 273 weight parts of Fe-Si-Al alloy powder as the soft magnetic powder mentioned above and further kneaded by the mixing roll. The kneading operation may be carried out by the use of a kneading machine, such as a kneader and an intensive mixer. Thus, the equivalent kneaded magnetic material can be obtained.

[0052]

The kneaded composite magnetic material thus obtained is rolled between rolls arranged in parallel to obtain a sheet-like composite magnetic body. In order to obtain such a sheet-like composite, use may be made of an extruder, press molding, or injection molding in addition to the above-mentioned rolls.

[0053]

Subsequently, the sheet thus obtained is heat-pressed to cause

cross-linking reaction. Thus, the sheet-like composite magnetic body is obtained.

[0054]

The composite magnetic body produced in the above-mentioned manner is used in an internal part or a peripheral part of an electrical apparatus or the like. Then, the composite magnetic body serves as an electromagnetic interference suppressor for suppressing electromagnetic interference caused by the interference from undesired electromagnetic waves.

[0055]

The following Table 5 shows the results of burning tests for the composite magnetic sheet of Example 4 mentioned above.

[0056]

As compared with Examples 1 to 3, the improvement in fire resistant characteristic can be confirmed and Class V-1 requirements are met in the UL 94V Vertical Burning Test.

[0057]

[Table 5]

Example 4	No.	Thickness (mm)	First Afterflame	Second Afterflame	Second Afterflame + Glowing	Class
silicone rubber (solid type) with Fire Retardant added	1	0.30	18	13	23	V-1
	2	0.30	21	11	22	
	3	0.30	16	15	25	
	4	0.30	19	18	33	
	5	0.29	12	16	22	

[0058]

Comparison was made of the total of the afterflame times (seconds) after the first flame contact and the afterflame times after the second flame

contact, that is, the total afterflame time after all of ten times of flame contact for the five specimens Nos. 1–5. In this event, the total time is equal to 263 seconds in Example 1 and 159 seconds in Example 4. Thus, the time of 106 seconds can be shortened.

[0059]

(Fifth Embodiment)

Like in Example 4, the samples are prepared using the same mixing composition except the soft magnetic powder and the same process. As the soft magnetic powder as a filler, use is made of Fe-Si-Al alloy powder obtained by further treating the Fe-Si-Al powder used in Example 4 for 5 hours by an attritor into flat-shaped particles and having an average grain size of 37 μm.

[0060]

First, 100 weight parts of solid silicone rubber as a binding agent, 2 weight parts of a cross-linking agent, and 55 ppm weight parts of platinum, 60 weight parts of silicon dioxide, and 2 weight parts of carbon black as a fire retardant are kneaded by a mixing roll to be dispersed. The mixture thus obtained is mixed with 273 weight parts of Fe-Si-Al alloy powder having a flat shape and further kneaded by the mixing roll. The kneaded composite magnetic material thus obtained is rolled between rolls arranged in parallel to obtain a sheet-like composite magnetic body.

[0061]

Subsequently, the sheet thus obtained is heat-pressed to cause cross-linking reaction. Thus, the sheet-like composite magnetic body is obtained.

[0062]

The composite magnetic body of this example was tested for a fire resistant characteristic. As a result, Class V-1 requirements are met in the UL 94V Vertical Burning Test, as shown in the following Table 7.

[0063]

Then, various experiments were performed in an attempt to further improve the fireproofing above Class V-1. However, if silicone rubber is combined with the soft magnetic powder, in particular, the soft magnetic alloy powder, the Flame Resistance Standard V-0 could not been met. This is because flammability is promoted due to the increase in catalytic action or thermal conductivity of the magnetic alloy powder. It is therefore very difficult to assure self-extinguishing characteristic, which is the main factor of the fire retardant characteristic. In addition, the soft magnetic metal powder itself is often an active flammable solid. Thus, it is more difficult to assure the self-extinguishing characteristic.

[0064]

In view of the above, an attempt was made to control the fire resistant characteristic by the grain size of the soft magnetic powder in order to assure the fire resistant characteristic. However, the grain size merely indicates dimensions of the powder and does not define the surface state of the powder, that is, the area of its surface in contact with air or other media. In addition, the difference in fire resistant characteristic results from the difference in distribution pattern of the grain size of the powder.

[0065]

(Sixth Embodiment)

As shown in the following Table 6, in Example 6 as a sample according to a sixth embodiment, attention is paid to a surface area as a physical value that could be used to specifically define powder properties. In view of the above, the composite magnetic body was produced by limiting the surface area of the soft magnetic powders in a range of 0.1 m^2/g –3 m^2/g.

[0066]

Herein, the results of the Vertical Burning Test UL 94V for composite

magnetic bodies different in surface area of soft magnetic powder are shown. The composite magnetic bodies were produced in the manner similar to Example 1 of this invention. Fig. 2 shows the results of the Vertical Burning Test UL 94V with respect to the surface areas of the soft magnetic powder. In case where the surface area is 0.1 m^2/g or less, the afterflame time after all of ten times of flame contact is about 10 seconds. In case where the surface area is 0.6 m^2/g, 1.4 m^2/g, and 2.6 m^2/g, the afterflame time is equal to 17 seconds, 20 seconds, and 37 seconds, respectively. In case where the surface area is 3.2 m^2/g above 3.0 m^2/g, the afterflame time is equal to 48 seconds. Furthermore, in case where the surface area is 4.1 m^2/g, the afterflame time reaches 415 seconds.

[0067]

As shown in the following Table 7, from the results concerning the surface area of the soft magnetic powder and the fire resistant characteristic of the composite magnetic body, it is revealed that, in order to meet Class V-0 requirements in the burning test, the surface area should be 3 m^2/g or less, in view of industrial productivity thereof,. In addition, even if the surface area is 0.1 m^2/g or less, Class V-0 requirements are met in the burning tests and the self-extinguishing characteristic can be assured. However, since the surface area is reduced, the magnetic characteristic is deteriorated so that the sufficient effect of suppressing the electromagnetic interference can not be obtained.

[0068]

The above also applies to the case where use is made of soft magnetic powder which is composed of Fe-Si-Al alloy similar in composition to Example 1 according to the first embodiment and which has a surface area less than 0.1 m^2/g. In this case, the self-extinguishing characteristic can be achieved. However, the magnetic characteristic is deteriorated due to reduction in flatness of the powder. As a result, the composite magnetic body

can not suppress the electromagnetic interference.

[0069]

In the embodiment of this invention, soft magnetic powder having a surface area of 1.6 m^2/g is used as a filler by way of example. In addition, the soft magnetic powder is Fe-Si-Al alloy powder and has an average grain size of 32 μm, like in Example 1. In order to facilitate comparison, the composite magnetic body is produced in the process similar to that used in Example 4.

[0070]

(Seventh Embodiment)

In one example according to a seventh embodiment of this invention, soft magnetic powder having a flat shape and an aspect ratio of 28 is used by way of example. By way of example, the soft magnetic powder is Fe-Si-Al alloy powder and has an average grain size of 32 μm, like in Example 1. In order to facilitate comparison, the composite magnetic body is produced in the process similar to that used in Example 4.

[0071]

As shown in the following Table 7, V-0 requirements in the UL 94V Vertical Burning Test are met in Examples 7 and 8.

[0072]

Then, consideration has been made about the case where the soft magnetic powder is highly charged into silicone rubber. Although the fire resistant characteristic can be assured, the magnetic characteristic was deteriorated due to the low powder filling ratio. In view of the above, the kneading time by mixing rolls was extended or the rotation speed ratio of the two rolls was set to 1.7 to enhance shearing so that the filling ratio of the silicone powder was increased. In this event, the magnetic characteristics were improved. However, moldability of the composite magnetic body is considerably degraded and its mechanical strength is significantly decreased.

[0073]

In view of the above, the composite magnetic body was molded after the soft magnetic powder is surface-treated with a coupling agent. As a result, magnetic permeability was improved from 12 to 17. This is because affinity between the soft magnetic powder and the binding agent was improved by the use of the coupling agent. In particular, by limiting the range of a SP value, that is, Solubility Parameter, the compatibility with silicone rubber is increased so that the composite magnetic body excellent in moldability was obtained. As the coupling agent, use may be generally made of titanate-based, aluminate-based, silane-based, and phosphate-based coupling agents. By the use of the former three types of coupling agents, the filling properties of soft magnetic powder is further improved because hydrophilic groups containing titanium, aluminum, and the like interact with the soft magnetic powder and chemically bond with the surface of the soft magnetic powder.

[0074]

[Table 6]

Mixing Composition	Example 6 (weight parts)	Example 7 (weight parts)
(Binding Agent) silicone rubber (solid type) platinum silicon dioxide carbon black	 100 55ppm 60 2	 100 55ppm 60 2
(Filler: Soft Magnetic Powder) Treatment by Attritor for 17 hours flat shape Fe-Al-Si alloy Average Grain Size: 32 μ m Surface Area: 1.6m^2/g	273	
Treatment by Attritor for 17 hours flat shape Fe-Al-Si alloy Average Grain Size: 32 μ m Surface Area: 1.5m^2/g Aspect Ratio: 28		273
Cross-Linking Agent	2	2

[0075]

[Table 7]

Example 5	No.	Thick-ness (mm)	First Afterflame	Second Afterflame	Second Afterflame + Glowing	Class
Flat-shaped Soft Magnetic Powder Treatment by Attritor for 5 hours	1	0.30	19	11	23	V-1
	2	0.31	22	13	20	
	3	0.30	20	16	24	
	4	0.29	18	18	28	
	5	0.30	23	20	30	

Example 6	No.	Thick-ness (mm)	First Afterflame	Second Afterflame	Second Afterflame + Glowing	Class
Soft Magnetic Powder Surface Area of 1.5m^2/g	1	0.29	4	1	5	V-0 Satisfied
	2	0.30	3	2	6	
	3	0.30	2	1	5	
	4	0.30	4	1	4	
	5	0.30	4	1	4	

Example 7	No.	Thick-ness (mm)	First Afterflame	Second Afterflame	Second Afterflame + Glowing	Class
Soft Magnetic Powder Aspect Ratio of 28	1	0.29	6	1	5	V-0 Satisfied
	2	0.30	5	2	6	
	3	0.30	3	1	4	
	4	0.30	4	3	7	
	5	0.30	7	2	4	

[0076]

(Eighth Embodiment)

Herein, one example is shown. The mixing composition of a composite magnetic body according to an eighth embodiment of this invention is shown in the following Table 8. A method of producing the composite magnetic body is as follows. First, 273 weight parts of the soft magnetic powder mentioned above and 3 weight parts of a titanate-based coupling agent having an SP value of 8.6 are stirred by a mixer or the like. Thus, surface-treatment is preliminarily carried out. During the surface-treatment of the soft magnetic powder with the coupling agent, a surface-treating agent may be diluted with a diluent or the like to achieve uniform surface-treatment.

Thereafter, the composite magnetic body is produced in the process similar to that used in Example 4 in order to facilitate comparison.

[0077]

As shown in the following Table 9, V-0 requirements can be met in the UL 94V Vertical Burning Test as a fire-resistance test.

[0078]

(Ninth Embodiment)

The mixing composition of a composite magnetic body according to a ninth embodiment of this invention is shown in the following Table 8. A method of producing the composite magnetic body is as follows. First, 273 weight parts of the soft magnetic powder mentioned above and 3 weight parts of a primer which has an SP value within the range between those of the soft magnetic powder and a binding agent and which is recommended by a silicone rubber maker are stirred by a mixer or the like. Thus, surface-treatment is preliminarily carried out. During the surface-treatment of the soft magnetic powder with the primer, a surface-treating agent may be diluted with a diluent or the like to achieve uniform surface-treatment.

[0079]

Thereafter, the composite magnetic body is produced in the process similar to that used in Example 4 in order to facilitate comparison.

[0080]

Concerning the fire resistant characteristic of the composite magnetic body obtained by this example of the invention, V-0 requirements can be met in the UL 94V Vertical Burning Test, as shown in the following Table 9,

[0081]

[Table 8]

Mixing Composition	Example 8 (weight parts)	Example 9 (weight parts)
(Binding Agent) silicone rubber (solid) platinum silicon dioxide carbon black	 100 55ppm 60 2	 100 55ppm 60 2
(Filler: Soft Magnetic Powder) Treatment by Attritor for 17 hours flat shape Fe-Al-Si alloy Average Grain Size: 32 μ m Surface Area: 1.5m^2/g Aspect Ratio: 28	273	273
(Coupling Agent) SP value: 8.6	3	
(Primer) SP value: Soft Magnetic Powder > Primer > silicone rubber	0	3
Cross-Linking Agent	2	2

[0082]

[Table 9]

Example 8	No.	Thick-ness (mm)	First Afterflame	Second Afterflame	Second Afterflame + Glowing	Class
SP value: 8.6 Coupling Agent	1	0.29	2	1	5	V-0 Satisfied
	2	0.30	4	2	4	
	3	0.30	4	1	5	
	4	0.30	3	1	6	
	5	0.30	3	1	4	

Example 9	No.	Thick-ness (mm)	First Afterflame	Second Afterflame	Second Afterflame + Glowing	Class
Treatment by Primer	1	0.29	2	1	5	V-0 Satisfied
	2	0.30	5	2	7	
	3	0.30	3	1	6	
	4	0.30	6	1	4	
	5	0.30	2	1	6	

[0083]

[Effect of the Invention]

As described above, according to this invention, silicone rubber is used as the binding agent of the composite magnetic body. It is thus possible to provide the composite magnetic body and the electromagnetic interference suppressor which contain no halogen taking into account the safety for the environment. In addition, the composite magnetic sheet according to this invention contains the soft magnetic powder having the physical properties defined in terms of the surface area to assure the self-extinguishing characteristic which is the main factor of the fire resistant characteristic. As a result, the Flame Resistance Standard Class UL94V-0 can be assured.

[Brief Description of the Drawing]

[Fig. 1]

A schematic sectional view showing the structure of a composite magnetic body according to an embodiment of this invention.

[Fig. 2]

A diagram showing the results of Vertical Burning Test UL94V with respect to a surface area of the composite magnetic body according to the embodiment of this invention.

[Description of the Reference Numerals]

1 composite magnetic body

2 soft magnetic powder

3 binding agent (silicone rubber)

[Name of Document] ABSTRACT

[Abstract]

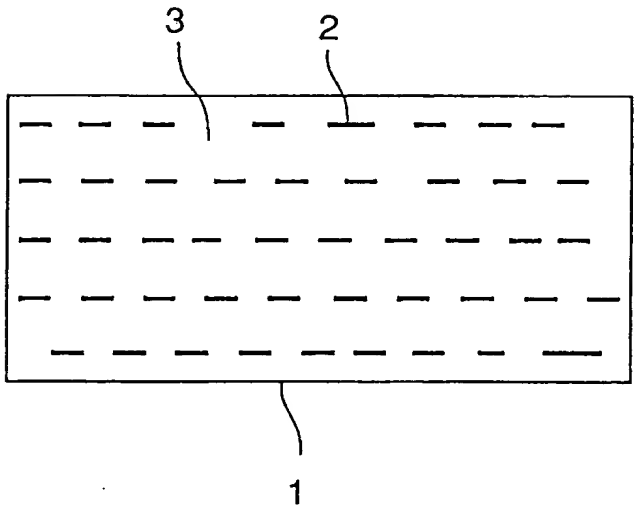
[Object] To provide a composite magnetic body and an electromagnetic interference suppressor which use no halogen-based materials, such as a halogen-based binding agent, for example, a resin or an elastomer binder, and a halogen-containing bromine-based fire retardant.

[Means for Solution] A composite magnetic body 1 comprises soft magnetic powder 2 and silicone rubber 3. The silicone rubber 3 is preferably solid silicone rubber or reaction-setting silicone rubber of a liquid phase.

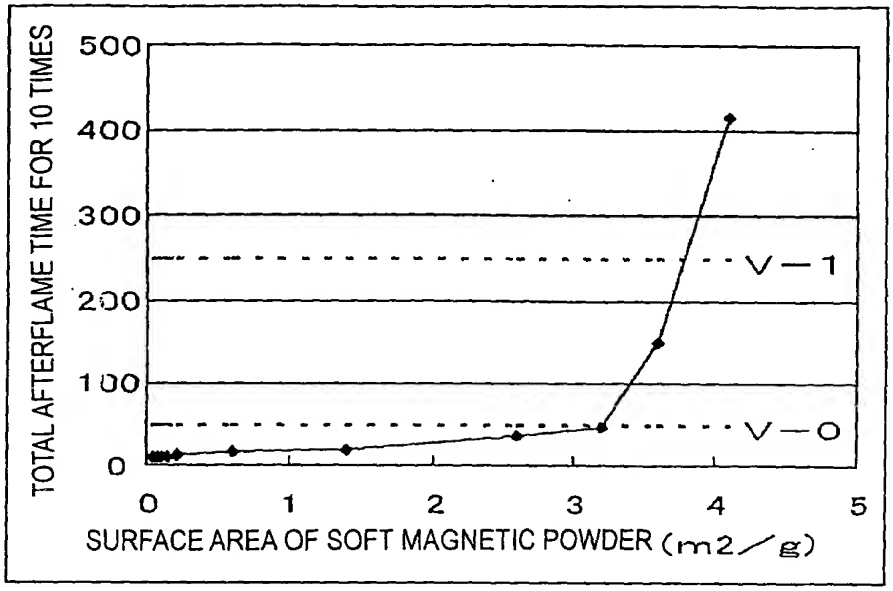
[Selected Figure] Fig. 1

[NAME OF DOCUMENT] DRAWING

[FIG. 1]



[FIG. 2]


TOTAL AFTERFLAME TIME FOR 10 TIMES
500
400
300
200
100
0
V—1
V—0
0
1
2
3
4
5
SURFACE AREA OF SOFT MAGNETIC POWDER (m2/g)